

Warnings of local frost were issued for Utah, western Colorado and the mountain districts of New Mexico on the 1st, as relatively high pressure prevailed on the western slope attended by abnormally low temperature. While frost temperatures occurred in places, with freezing weather in northeastern Arizona, a considerable rise in temperature prevented further serious damage. Frost warnings for western Utah were issued on the 13th, when the pressure was low in Rocky Mountain districts and an anticyclonic area was advancing eastward from the middle Pacific. Frost temperatures occurred in localities. On the 22d advices of possibly local frost were issued for western Utah. The center of an area of low pressure occupied the middle Rocky Mountain section, with cooler weather in the Plateau region, frost in Nevada, and rising pressure on the California coast. The rapid development of an area of low pressure of considerable intensity in Nevada was attended by rising temperature.—*Frederick W. Brist.*

SAN FRANCISCO FORECAST DISTRICT.

During the month of June the high-pressure area over the eastern portion of the North Pacific Ocean was slower than usual in gaining strength and stability; consequently it did not impinge on the coast to any great extent till near the end of the month. The result was the formation of irregular-shaped troughs of low pressure over the Rocky Mountain and Pacific States that caused protracted spells of cool and unsettled weather in the San Francisco Forecast District. The passage eastward of these trough-shaped low-pressure areas was more or less checked by the presence of persistent high-pressure areas over the Mississippi Valley and the Atlantic States. This type of weather while difficult to predict was of inestimable benefit to the grain crops, and it did much to prevent the spread of forest fires, which sometimes are numerous at this time of the year, especially in the southern portion of the district.

The only warning issued was for light-to-heavy frost in exposed places in Idaho on the 16th inst. No storm warnings were issued nor were any necessary.—*E. A. Beals.*

RIVERS AND FLOODS.

By H. C. FRANKENFIELD, Meteorologist.

The only great flood of the month occurred in the Arkansas River from the vicinity of Hutchinson, Kans., to the mouth of the river. To the westward, the river was only in moderate flood, and flood stages were not reached except at Fort Lyon, Colo., where the river was above the flood stage of 6 feet on June 17, with a crest stage of 10 feet at 8 p. m.

It is evident that the major portion of this rise came from the Purgatoire River, at Higbee, Colo., on that river, reported the washing out of the river gage on June 17, at a stage of 10 feet, or 6 feet above the flood stage, with the river still rising. Flood warnings for the Arkansas River from Fort Lyon to the Kansas line were issued at once, and no serious damage was reported, as the excess water was apparently diverted to the irrigation canals. Other streams in northeastern Colorado were also in flood.

The following account of the flood from Hutchinson, Kans., eastward was summarized from the detailed reports of Messrs. S. P. Peterson, T. G. Shipman, H. S. Cole, and J. P. Slaughter in charge of the river districts—

Wichita, Kans., Fort Smith, Ark., Little Rock, Ark., and Oklahoma City, Okla., respectively. The rainfall responsible for the floods is shown in the following table:

Rainfall, May 21 to June 17, inclusive, 1923.

Station.	River.	Total for 28 days. Inches.
Macksville, Kans.	Arkansas.	9.31
Great Bond, Kans.	do.	9.90
Hutchinson, Kans.	do.	11.01
Medora, Kans.	do.	12.73
McPherson, Kans.	do.	11.04
Hesston, Kans.	Little Arkansas.	11.93
Newton, Kans.	do.	12.69
Sedgwick, Kans.	do.	13.13
Wichita, Kans.	Arkansas.	18.36
Ralston, Okla.	do.	6.14
Tulsa, Okla.	do.	11.35
Webbers Falls, Okla.	do.	8.52
Emporia, Kans.	Cottonwood.	12.13
Neosho Rapids, Kans.	Neosho.	10.06
LeRoy, Kans.	do.	9.60
Iola, Kans.	do.	8.69
Oswego, Kans.	do.	7.97
Wyandotte, Okla.	do.	12.27
Okay, Okla.	Verdigris.	7.13
Fort Gibson, Okla.	Neosho.	6.96
Camargo, Okla.	North Fork Canadian.	7.97
Union City, Okla.	do.	7.36
Woodward, Okla.	do.	9.53
Canton, Okla.	do.	8.22
Reno Junction, Okla.	do.	5.47
Oklahoma City, Okla.	do.	7.21
Calvin, Okla.	Canadian.	8.80
Fort Smith, Ark.	Arkansas.	8.65
Dardanelle, Ark.	do.	8.24
Danville, Ark.	Petit Jean.	8.25
Little Rock, Ark.	Arkansas.	5.19
Calico Rock, Ark.	White.	8.98
Batesville, Ark.	do.	8.91
Newport, Ark.	do.	12.56
Pine Bluff, Ark.	Arkansas.	6.07
Black Rock, Ark.	Black.	7.71
Patterson, Ark.	Cache.	14.66
Georgetown, Ark.	White.	11.95
Clarendon, Ark.	do.	7.87

It will be seen from the above table that there was a period of almost four weeks of continuous rains over eastern Kansas, Oklahoma, and Arkansas. From May 21 to 24, inclusive, the rains were heavy. On June 9, they were excessive over Kansas and Oklahoma, and on June 10 over Arkansas. The mean rainfall for the 28 days over the three sections mentioned was 9.60 inches, from two to more than three times the normal amount for the season, with the greatest excess over southeastern Kansas.

Hutchinson, Kans., to Wichita, Kans.—The area covered by the heavy rains was about 45 miles in length, 60 miles in width over the upper portion, and 40 miles over the middle portion, converging to about 10 miles at the extreme lower end. The flooded area was about 40 miles in width at Hutchinson, Medora, and McPherson, Kans., and became extensive southward from a line crossing the drainage area through the headwaters of Big Slough and at Hesston, Kans. The total area of farm lands flooded was about 97,000 acres and the reported damage to crops amounted to \$942,000. Damage to highways and bridges amounted to about \$95,000 and to railroads about \$335,250. In the city of Wichita, situated at the convergence of the Big and Little Arkansas Rivers and Chisholm Creek, the damage amounted to about \$840,750, making a total for the district of about \$2,213,000. About 6 square miles of the city was flooded. The crest stage in the Arkansas River at Wichita was 13.5 feet, 4.5 feet above the flood stage and the highest stage of record, and the river was above the flood stage from June 9 to 15, inclusive.

Previous high-water stages were 11 feet on May 18, 1877, 11.2 feet on Jan. 13, 1910, and 12.1 feet on June 6, 1921. The city overflow water came from the smaller

streams, the main river overflowing only a little property in the southern portion of the city. Since 1904 the river channel has been artificially deepened by the pumping of sand for commercial purposes, and the maximum deepening has been about 7 feet. Below Wichita the overflow was as great as in 1904.

Warnings were issued in ample time for Wichita and vicinity, but it was not possible to reach the upper portion of the flooded area, as the rapid rise of the streams followed too closely the heavy rains of the afternoon and evening of June 8. Appreciation of the excellent service was general, and a number of commendatory letters was received.

Below Wichita, Kans., to Fort Smith, Ark., including tributaries, except the Canadian River.—The floods over this district were much more extensive and destructive than elsewhere. The flood period lasted from June 9 to 22, inclusive, and the highest stages of record were experienced at four stations, Yonkers, Okla., on the Neosho River, and Ralston, Tulsa, and Tamaha, Okla., on the Arkansas River. Only the breaking of levees prevented record stages at Fort Gibson, Okla., on the Neosho River and at all places on the Arkansas River from Tulsa, Okla., to Fort Smith, Ark.

The floods were also unusual in that the causative rainfall occurred mainly over the northern and western portions of the district and beyond. Six different rises from six different sources occurred in the lower Arkansas River in eight days, the first from eastern Oklahoma, the second from the Canadian River, the third from the Neosho River, the fourth from the Cimarron River, the fifth from the upper Arkansas River, and the sixth from the Spring River, a tributary of the Neosho River in southwestern Missouri and northeastern Oklahoma. At no time since the beginning of gage readings have the Neosho and upper Arkansas Rivers shown such high stages simultaneously as during this flood. The severest floods passed through a country rich in agricultural and mineral resources, and in a high state of development, and the resulting damage far exceeded any previous records.

The losses in the district were estimated at \$15,988,300, divided as follows:

Railroads (incomplete).....	\$1,505,300
Buildings, etc.....	8,922,000
Crops, mature.....	283,000
Crops, prospective.....	3,294,000
Movable property and live stock.....	774,000
Suspension of business.....	1,210,000

The acreage of overflowed lands was estimated at 191,820. The district most affected was Cowley County, Kans., and adjoining territory. The reported losses totaled \$10,240,000, with the Winfield, Kans., section as the heaviest loser. Here 50,000 acres of land were overflowed, and the total losses were about \$2,500,000. Losses in Kay County, Okla., amounted to \$1,440,000.

Seven lives were lost during the flood.

The warnings of these floods were issued promptly and as frequently as occasion demanded, and the reported value of property saved thereby was \$1,130,000.

Canadian River drainage area.—Excessive rains over central and northwestern Oklahoma on May 21–22, 1923, caused a general flood in the North Fork of the Canadian River. Warnings were issued on the morning of May 22, and again on May 26, the warnings of the latter date including a statement that the river east of Oklahoma City would go over its banks during the following week. Another heavy rain necessitated an additional warning on the morning of May 28.

The crest stages reached were from 3 to 4 feet above the flood stages, as a rule, and high water continued at the close of the month, and one life was lost, that of a man engaged in rescue work in Oklahoma City.

New high-water records were established at each of the four river stations on the North Canadian River. The stages are shown in the table at the end of this report.

Warnings were issued for these floods at the proper time, and their distribution was facilitated by the hearty cooperation of the State board of agriculture, both physically and financially. The newspapers also performed valuable service, as flood waters in the Canadian River move very slowly, and press warnings reached every community several days in advance of the crest of the flood.

It has been impossible to obtain even a rough estimate of the amount of damage. The figures submitted were so indefinite, incomplete and conflicting as to be valueless. It is known that the overflowed acreage was less than in the May flood, and the total loss and damage for the two floods probably aggregates between \$5,000,000 and \$10,000,000, of which several millions fell to Oklahoma City.

While the June rise in the Canadian River was decided, flood stages were not reached except locally at a few places. Warnings were issued immediately after the heavy rains of June 7–9, and there was very little loss or damage. In the Cimarron River the flood was destructive, and railroad traffic over north-central Oklahoma was suspended for about one week. No flood service is maintained on this river.

Arkansas River below Fort Smith, Ark.; White and Black Rivers.—The flood in this district formed a part of the general flood scheme. The Arkansas River flood was of about the same duration as farther westward, but it was neither so severe nor destructive.

In the lower White and Black Rivers the floods were more prolonged.

Frequent warnings were issued for the floods, and preventable losses were reduced to a minimum. The reports of losses, which were very incomplete, totaled \$1,189,700, of which \$1,107,000 was in crops, matured and prospective. A live-stock loss of \$500 was due to the unexpected breaking of a levee, and the reported amount of property saved by the warnings was \$45,500.

Rivers of Kansas, except the Arkansas River.—(Summarized from the report of Mr. S. D. Flora, Topeka, Kans.) The same rainfall conditions that caused the great flood in the Arkansas and Canadian Valleys, also caused general, although much more moderate, floods in the other rivers of Kansas. The Solomon, Republican, Smoky, Hill and Osage Rivers were in flood between June 9 and 14, doing damage to the estimated amount of \$382,800, mainly to bridges and growing crops. Bankful stages only prevailed in the Blue River, and only a few hundred acres of growing crops were damaged. The greatest losses occurred over a limited area along the Republican River just below the Nebraska line. No towns were flooded except Scandia, Kans., within the area just mentioned, and the lower portion of Ottawa on the Osage. Personal property loss was insignificant.

Timely and very accurate warnings were issued for the Kansas River and Osage, and many thousands of dollars' worth of property were saved. The following quotation from the "Topeka Daily Capital" of June 17, 1923, indicates the value of the warnings.

All sorts of rumors of cloudbursts and great rises above were circulated by irresponsible persons, but North Topeka stood pat on the official prediction, took whatever precautions were necessary for a

twenty-one foot stage, and refused to be stampeded. The results entirely vindicated their faith in the bureau's prediction.

Sunday evening, after the heavy downpour, when the river stood almost on a level with North Kansas Avenue, many of the north siders were almost panic-stricken but in half an hour's time the Weather Bureau had received reports from its observers upstream that showed there was no chance for an overflow from this rain and North Topeka went to bed feeling that its levees would take care of all the water that was coming. This particular warning cost the Weather Bureau exactly 90 cents in telegraph and telephone tolls and a few hours of the hardest kind of work on the part of employees already worn out with long vigil over flood conditions, but it saved North Topeka upwards of \$25,000, besides all the inconvenience of moving out and moving back again.

Warnings for other sections were equally accurate and allayed the fears of thousands of people who had become panic-stricken through unfounded and grossly exaggerated rumors.

South Platte and Loup Rivers of Nebraska.—(From report of Mr. M. V. Robins, Omaha, Nebr.) Early in this report it was stated that floods occurred in north-eastern Colorado. The flood waters in the South Platte River moved through the State of Nebraska, causing a considerable rise in the river. Warnings were first issued on June 13, and again on June 15, 16, 17, and 18. The flood was a moderate one, and the only damage reported, amounting to about \$5,500, was in the vicinity of Ogallala, Nebr., with an offset of \$1,500 worth of property saved through the warnings. At North Platte, Nebr., no damage was done, and the money value of property saved by the warnings was \$50,000.

On June 18 there were more heavy rains over the upper South Platte drainage area and that of the Loup River in Nebraska, and warnings were again issued on June 19. This flood caused considerable damage along the Platte River (below North Platte, Nebr.), and in the Loup Valley, the total amounting to about \$300,000, mainly to crops and live stock. It was impossible to obtain estimates of the value of property saved through the warnings, but it was reported that a number of herds of cattle was saved.

These floods were the first since the recent organization of flood service along the Platte River, and the success attending the warnings was very gratifying. It became apparent that some further extensions are necessary if the needs of the people are to be met, and additions will be made if funds can be obtained.

The Platte, Kansas, and Osage floods were just about sufficient to bring the Missouri River to approximate flood stages from Kansas City eastward. Some warnings were issued at the proper time and apparently little or no damage was done.

The Santee River of South Carolina fell below the flood stage on June 12. The river had been above flood stage so long that no crops of consequence had been planted in the lowlands, and livestock kept within bounds. There were therefore no losses. The local floods in the Oconee, Ocmulgee and Flint Rivers of Georgia and in the Apalachicola River of Florida were unimportant.

The St. Francis River of Arkansas reached the flood stage of 17 feet at Marked Tree, Ark., on May 18, and did not fall below that stage until June 19. The highest stage was 19.1 feet from May 28 to June 1. Warnings were first issued on May 16, and thereafter as occasion required, the last on June 11, after the heavy rains of June 10-11.

The flood was not as destructive as its height and the season of the year would indicate. The absence of high stages in the Mississippi River prevented ponding in the lower reaches and the wet spring had seriously retarded farming operations. About 10,000 acres of land were overflowed and their crops destroyed, although perhaps

one-half was replanted to corn. Lumbering operations were aided in some localities and hindered in others. The most serious loss was in farm labor which moved away from the flooded area and for the most part failed to return.

Losses were about \$275,000, of which \$200,000 was in crops about equally divided between mature and prospective yields. Property to the value of \$50,000, was saved through the warnings.

The Yazoo River flood ended about July 4, the river having been in flood since March 1. The only losses resulted from the overflow of about 1,500 acres of cultivable lands, and were, of course, prospective. They were estimated at \$15,000.

Five hundred and sixty-eight square miles of land in the lower basin were overflowed by backwater from the Mississippi River, but owing to the frequency of floods, cultivation of the lands in this section has virtually been abandoned. There still remain about 2,140 square miles that are protected from overflow.

LOW WATER IN THE MISSISSIPPI RIVER DURING JUNE, 1923, IN THE DAVENPORT, IOWA, DISTRICT.

By A. M. HAMRICK, Meteorologist.

[Weather Bureau, Davenport, Iowa.]

During June, 1923, the Mississippi River was far below the average stage for that month in the Davenport, Iowa, district. Gage readings at Davenport show that in only four of the last fifty years have June river stages averaged lower than this year. The lowest water for any June occurred in 1900, when the daily gage readings averaged 2.2 feet, with a low stage for the month of 1.4 feet, and a high stage of 3.2 feet. The other three low-water Junes were: 1891, with an average stage of 2.8 feet; 1910, with an average stage of 3.1 feet; and 1887, with an average stage of 3.2 feet. In June, 1923, the average river stage was 3.5 feet, with a high reading of 4.3 feet, and a low reading of 3 feet.

The normal stage of the Mississippi River for June at Davenport, as determined from the records of the last 50 years, is 7.24 feet.

No flood occurred in this section of the Mississippi River during the spring of 1923, although the April stages averaged slightly above normal. The May stages were 1.7 feet below normal.

The total rainfall at Davenport during May was 3.60 inches, 0.59 inch below normal, and during June it was 6.03 inches, or 1.92 inches above normal. A drought prevailed throughout this section of the Mississippi Valley during April, and the heavy rains in May and June had very little effect upon the stages of the river.

The accompanying table gives the average daily river stages at Davenport for June for the last 50 years.

Average stage (feet).		Average stage (feet).	
June 1873.....	11.2	1899.....	9.2
1874.....	5.5	1900.....	2.2
1875.....	7.3	1901.....	3.6
1876.....	9.5	1902.....	7.3
1877.....	5.4	1903.....	9.9
1878.....	5.1	1904.....	8.1
1879.....	5.4	1905.....	11.3
1880.....	12.3	1906.....	9.6
1881.....	8.2	1907.....	7.0
1882.....	8.8	1908.....	11.5
1883.....	8.1	1909.....	8.4
1884.....	6.8	1910.....	3.1
1885.....	6.5	1911.....	4.4
1886.....	4.3	1912.....	6.8
1887.....	3.2	1913.....	6.3
1888.....	10.7	1914.....	7.7
1889.....	4.2	1915.....	7.9
1890.....	9.0	1916.....	11.3
1891.....	2.8	1917.....	7.5
1892.....	14.8	1918.....	8.2
1893.....	8.0	1919.....	6.1
1894.....	6.8	1920.....	7.2
1895.....	3.5	1921.....	5.9
1896.....	7.9	1922.....	4.8
1897.....	5.9		
1898.....	5.5	50-year mean.....	7.24

As a result of the excessive rains of June 9-10, the upper Trinity River of Texas overflowed low places from